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ABSTRACT

This research gauged the impact of school size on student achievement by modelling the educational process and then examining the influence of size on that process. Using data for students and teachers from over 300 districts nationwide, the analysis identified factors that differ significantly between smaller and larger schools. There are fewer differences among student and community background characteristics than among factors over which policymakers have greater control--teacher and principal characteristics, school climate, and types of school personnel per student. The effect of these differences on student achievement is not large going from a small school to a moderately sized school, but very substantial going from moderate-size to large schools; in the latter case the difference is more than a quarter of the average gain in annual student achievement. This negative association between large schools and student achievement calls for additional investigation, especially since some large school characteristics are susceptible to policy or administrative manipulation. (Author/KS)

The Effect of School Size on Student Outcomes

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Abstract

In this research, we gauged the impact of school size on student achievement by modelling the educational process first, and then by examining the influence of school size on the educational process. Using data for individual students and teachers from over three hundred school districts nationwide, our analysis identified a number of factors that differ significantly between smaller and larger schools. Surprisingly, there are fewer differences among student and community background characteristics than among factors over which educational policymakers presumably have greater control--teacher and principal characteristics, school climate, and various types of school personnel per student. The ultimate effect of these differences on student achievement is not large going from a small school (under 200 students) to a moderately sized school (under 800 students), but it is very substantial going from a moderately sized school to a large school (over 800 students)--more than a quarter of the average gain in student achievement in any one year. Such a strong negative association between very large schools and student achievement clearly calls for additional investigation, especially since some of the characteristics of large schools (if not the size of the school itself) are susceptible to policy or administrative manipulation.

INTRODUCTION

In this report we examine the relationship between school size and factors related to administrative or instructional leadership. We also explore whether school size is related to both the quality and quantity of instructional time in mathematics and, ultimately, student achievement in this area. Research has suggested that student achievement may be influenced by school size (Coleman et al. 1966; Summers and Wolfe 1977), but there is no consensus regarding the way school size may affect student outcomes (Fox 1981). Further work is needed to explore the relationship between school size and student achievement using data linking individual student achievement data to relevant teacher, principal, and school variables; and methodological strategies that control for a variety of other possible determinants of student achievement besides school size.

We are especially concerned with administrative leadership as one determinant of student achievement and its relationship to school size. School size may affect the likelihood that principals will be actively involved in classroom observation, curriculum coordination, program evaluation, and general support of teachers. The school effectiveness literature suggests that these behaviors are linked to greater student achievement. Testing the linkages between school size, administrative leadership, and student achievement is important as school size is one variable that is directly controlled by district policy decisions. Administrative behavior may also be altered by district policy decisions to improve school effectiveness.

Both the results of recent research and changing political and demographic conditions facing public schools today suggest a need for re-examining the assumption prevalent over the last half century that bigger schools are more effective (Callahan 1962; Tyack 1974; Conant 1959). The average size of secondary schools has almost tripled in the past fifty years (Sher and Tompkins 1977) and the average size of elementary schools has also increased considerably (Guthrie 1979). Paul Lindsay (1982, pp. 57-58) gave the following explanation of his research exploring the potential effects of school size on student participation, satisfaction, and attendance:

> ...though an increase in organizational size leads to greater specialization (Blau 1970, 1973), it is not clear that more specialization leads to more student learning (Averch et al. 1974; Spady 1973). In fact, several recent studies question whether either economic efficiency or desired student outcomes are enhanced in larger schools (Guthrie 1979).

The prevalence of school closures as an educational, economic, and political issue in school districts (Boyd 1982; Zeigler et al. 1981) has generated a resurgence of interest in the relationship between school size and school effectiveness. In fact, in a 1981 Gallup Poll, when people were asked to identify important problems with which the public schools must deal, the response "large schools" ranked in the seven most common replies. Moreover, adults with children in public schools were twice as likely as parents with no children in public or private schools to cite "large schools" as a major problem. Moreover, parents of private school students cited "large schools" as a problem of the public schools twice as often as did parents of public school children. Since private schools are on average smaller than public schools (Chambers 1981), this may partially explain the growth in private school enrollments. At any rate, the fact that declining enrollment in the public schools continues to be a major problem noted by superintendents, principals, and board presidents (Duea 1982) indicates that school closure decisions will continue as an important issue in the educational policymaking arena throughout this decade. Therefore, better information on the relationship between school size and school effectiveness may guide administrators and policymakers on decisions regarding which schools to close.

Due to the already extensive literature on economies of scale regarding school size (Sher and Tompkins 1977; Cohn 1974; Hickrod 1975), in this report we will not explore the relationship between cost and school size. Research has recently been conducted in this area to show how declining enrollments (Riew 1981) and transportation cost (Kenny 1982) might affect a school official's decision about whether a certain size school is cost-efficient. Neither will we examine how school size affects the breadth of curricular offerings (For example, special courses in music, art, and the humanities) as others have previously done (Conant 1959). Rather we are concerned with how school size affects student achievement in a basic skill area such as mathematics, as well as its relationship with administrative leadership as a possible determinant of student achievement. We have chosen to focus our examination on effects on mathematics achievement because we feel that mathematics achievement is influenced less by home-level variables than is reading achievement. Therefore, effects in mathematics are likely to be more visible (Madaus et al. 1979).

Administrators and board members need more information about the relative cost-effectiveness of schools of various sizes. While information on cost has been a focus of past research (Fox 1981), little is known about the effectiveness side of the issue. Fox, for example, has recently provided an excellent review of the research on economies of scale, but notes that much of the past research relating school size to educational outcomes has been flawed due to problems with the research design or the adequacy of available data. James and Levin (1970) reached a similar conclusion in their earlier examination of the literature on school size and its relation to student achievement. We anticipate that due to improved methodological techniques and a large, in-depth data base, our study will provide useful information not only about whether school size is related to school effectiveness, but also how it may be related.

I. Theoretical Framework

Our study of the relationship between school size and achievement may be affected by the relationship between school size and administrative leadership. Here we will examine differences in principal characteristics, attitudes of principals regarding teachers, and attitudes of teachers regarding principals' leadership abilities across schools of various sizes. However, in order to separate out the independent effects of administrative leadership we must also take into account how school size may be related to other determinants of student achievement such as student characteristics, teacher characteristics, and time teachers spent in instruction, preparation and administration. These relationships, plus a detailed description of how administrative leadership may be correlated with school size, are discussed below.

Student Characteristics

A number of studies have recently suggested that school size affects certain student characteristics such as student attendance, student satisfaction, and student participation in extra-curricular activities (Huling 1980; Barker 1978; Gump 1978; Lindsay 1982). We are encouraged that school size is a policy variable well worth the consideration of researchers as a means to improve policy and practice in schools. Lindsay (1982) found size independent of the effects of socioeconomic status, academic ability, and the urban or rural location of the school--size to be significantly negatively related to student participation in extra-curricular activities, attendance, and satisfaction.

If school size affects student satisfaction with required courses and attendance, we reason that it is also logical to test how school size affects students' performance in basic skills such as reading and mathematics. (Here we focus on mathematics.) Murnane reported that many principals he had interviewed felt that "small schools were more effective in the inner city" (1975, p. 105). Like Lindsay, we will also hold constant for socioeconomic status and academic ability so that we can examine the independent effects of variables that can be more readily influenced by district policy changes aimed at school improvement.

Teacher Characteristics

The relationship between school size and teacher characteristics may have important implications for educational policy decisions. In a recent article in Phi Delta Kappan, Dunathan, a teacher educator at the University of Missouri, stated that small schools already have difficulty attracting and retaining qualified teachers and that this condition may be expected to worsen over the next ten years. Moreover, the continuity of the educational program in small schools may be disrupted by teacher turnover which is often three to five times as high as for the average school (Dunathan 1980). If this picture is an accurate one, it underscores the necessity for an examination of the relationship between school size and student achievement, holding constant for factors such as length of teacher experience, educational background, and degree of curriculum coordination in the school.

In support of smaller schools, Ayrault and Crosetto hypothesize that the degree of teacher participation in school-level decisions, such as those related to hiring or helping to orient a new teacher, is greater in small schools because "teachers realize that even one new teacher will have a significant impact on the school" (1982, p. 61). We will examine how school size actually does relate to teacher attitudes towards school decision-making processes and climate using an extensive data set, rather than relying on a case study of one school as did these authors. Additional prior research indicates that school size may affect teacher morale and engagement in teaching, since teacher sick leave is positively related to school size (Winkler 1980). He found this to be even more significant for absences on Fridays and Mondays, a possible proxy for teacher job satisfaction.

Instructional Process

Prior research also indicates that school size may be related to student achievement through the way it affects the instructional process. Eberts (1984) found a significant inverse correlation between school size and time teachers spend on instruction. One might also expect school size to be related to the mode of instruction in terms of class size and the degree to which the instructional program is individualized. A study by Erickson and Nault (1978) suggested that the benefits of small schools included a greater probability that teachers would become more familiar with individual students' needs and an increased likelihood that parents would get involved in their child's educational program.

Administrative Leadership

In an atmosphere of concern about low student achievement in the public schools, many have become increasingly interested in exploring administrative leadership as a means of exploring school effectiveness. A number of studies have provided evidence that administrative leadership is indeed a promising area for research relating to school improvement. For example, Keeler and Andrews (1973) found that the leadership behavior of the principal, as perceived by his or her staff, was significantly related to the productivity of the school (Miller 1976, p. 337). More recently a number of other researchers have provided corroborating evidence in support of the hypothesis that school principal involvement in instructional leadership is correlated with improved student outcomes (Eberts and Stone 1984; Edmonds 1979; Brookover et al. 1977; and Wellisch et al. 1978).

While instructional leadership has been defined in a variety of ways, we generally use this term as encompassing program evaluation, supervision and support of teachers, and curriculum development and coordination. Although other researchers may have used somewhat different measures of administrative or instructional leadership, we have benefitted greatly by the results of their research on the relationship between administrative leadership and student achievement. For example, the findings of Wellisch et al. suggest that administrative leadership can lead to better schools and that leadership includes an interrelated and complex set of functions that require further exploration. They summarize these results as follows:

> Three characteristics of administrators were examined in relation to student achievement; how strongly administrators felt about instruction, whether they communicated their ideas concerning instruction, and the extent to which they assumed responsibility for instruction. Because they were related to each other and school success, and because the term is in accord with common sense meanings, this cluster of characteristics was termed "administrative leadership in instruction" (1978, p. 215).

In addition, principals in schools where there had been student achievement gains were significantly more likely to "review and discuss teaching performance regularly with their staff" (p. 217). Wellisch et al. also reported that principals and teachers in these more successful schools were significantly more likely to report a high degree of program coordination.

Currently there is much debate about the potential of administrative leadership as a key to increased student achievement. While the studies noted above support the notion that principal involvement in instructional leadership will lead to school improvement, others have found that principals who actively engage in such activities are indeed rare (Deal et al. 1975; Lortie 1969; Corwin 1970; Cohen and Miller 1980). Moreover, even researchers who accept the notion that instructional leadership is linked to school improvement have asserted that this leadership is not necessarily embodied in the principal per se, but rather that there are critical support functions that must be carried out. These support functions may be performed by a variety of school personnel other than the principal, including curriculum specialists, department heads, and teachers (Gersten and Carnine 1981). Finally, yet others caution that even when principals engage in the comprehensive set of tasks referred to as instructional leadership, the participation of teachers must also be considered as a critical variable (Wellisch et al. 1978). (Unfortunately, however, Wellisch et al. do not include a measure of the participation of teachers in their study.) Therefore, we have explored the relation of student achievement to both administrative leadership and the degree to which teachers work well together and feel that the instructional program is well-planned.

II. Research Design and Methodology

In our research we utilize regression analysis, by estimating an educational production function. We do so to examine how various key educational inputs may be related to gains in achievement test scores in mathematics of individual students. Lawrence Lau describes the educational production function method as follows:

> An educational production function is a function which relates the levels of identifiable educational outcomes to quantities of identifiable educational inputs. It is a fundamentally micro-economic concept, designed to apply at the level of an individual student. However, empirical estimation of educational production functions has been based on data aggregated to different degrees on both the output and/or the input sides as well as on individual student data (1979, p. 33).

In this examination of the relationship between certain educational inputs and achievement in mathematics we have utilized an achievement-gains model. This model reflects the concern that prior achievement in mathematics should be considered as a predictor of achievement in mathematics in a later time period, and therefore should be held constant in an attempt to discern what other types of input variables may be related to student achievement. The additional input variables we utilize take into consideration the following potential influences on student achievement in mathematics: student background characteristics (sex, race, childhood experience, parental involvement, economic status), teacher characteristics (years experience teaching, highest degree, courses taken in mathematics in the last three years, hours of inservice training in mathematics taken in the last three years) and principal characteristics (years experience in teaching, years experience in administration, highest degree, hours per year spent in curriculum development in mathematics, and hours per year spent in needs assessment, program planning, and program evaluation related to mathematics and a composite measure of "instructional leadership" including the last two sets of variables). We have also taken into account variables related to time teachers spend on various types of tasks relating to instruction, preparation, and administration. Additionally we include the ratio of administrators, teachers, and office personnel per student as a measure of the human resources available for assisting in the task of "producing student achievement." Finally, since we believe principal and teacher attitudes about instructional management are important, we examine how these may be related to student achievement in mathematics. Teacher attitudes include the degree to which: the principal is an effective leader overall, the principal is encouraging and supportive, the school program is well planned, the principal provides active leadership related to the mathematics program, the teachers work well together and are kept well informed, and conflicts are identified and resolved. The above set of attitudinal data with the exception of the first two items, was also included in the educational production function with the principal as respondent.

Data

Integrating the various determinants of student achievement with school size is an ambitious task. It requires a data set that has variables which relate both to the basic learning process and the institutional and governance structure of school systems. Fortunately, the "Sustaining Effects Study," conducted by the Systems Development Corporation (SDC) contains many of the variables needed to examine the issue of student achievement, administrative leadership, and school size (Hemenway et al. 1978).

To lessen the cost of data analysis, this particular investigation utilizes a subsample of the original SDC data set which includes information (the specific variables used are described above) from three hundred and twenty-eight schools. This subsample was partitioned further into five subsamples on the basis of school size. The criteria used for partitioning the sample are described in the next section.

III. Findings

The purpose of this section is to report how the process of education compares across schools of varying sizes. This includes both an examination of how the inputs or levels of resources related to schooling may differ across schools depending on the size of the school in terms of numbers of students and an exploration of how changes in the degree to which these resources are effectively utilized will influence student achievement in mathematics. We will also attempt to determine the joint influence of the two types of changes (in levels and utilization of resources) on student achievement.

Differences in Levels of Resources

In the first part of this analysis we are concerned with the levels of resources available for use in schools of varying sizes. This information does not tell us that the resources are necessarily utilized to positively affect student achievement, but merely that they are available. The next section will discuss the utility of these resources across schools according to size. However, we will pay particularly close attention to changes in levels of resources which past research has shown to be related to student achievement. We have already found the following school-related variables to be major determinants of student achievement in mathematics: teacher instruction time, teacher preparation time, teacher experience, principal involvement, principal experience in teaching, principal experience in administration, and teacher-student ratio. These findings are generally consonant with past research. Teacher experience has been found to be positively related to student achievement in both mathematics and verbal skills (Murnane 1975; Hanushek 1972). Recent studies have hailed the importance of students' time on task (Fisher et al. 1980, Goodlad 1983) so it seems logical that the time teachers spend in instruction and preparation would increase student achievement. Similarly, a variety of researchers have argued that in order to promote effective schools the principal should be a strong instructional leader (Wellisch et al. 1978; Edmonds 1979). One might expect that principal experience in both teaching and administration as well as the degree to which he/she becomes involved in the educational program will affect his or her ability to promote instructionally effective schools. Finally, while the results are mixed, other researchers have found the teacher-student ratio to be positively related to student achievement in both reading and mathematics (Bidwell and Kasarda 1975). Consequently, while we will examine the utility of various educational resources after disaggregating the data to estimate educational production functions for small, medium, and large size schools, we will pay special attention to changes in both the level and utility of these particular kinds of educational resources. In addition we will emphasize the influence of school-related variables rather than student background characteristics, as it is those variables which educational policymakers can more easily influence to promote greater student achievement.

Separate educational production functions have been estimated after partitioning the sample into five subgroups on the basis of school size. School size was measured on the basis of the average number of students in attendance (ADA). The range of sizes, mean, and the number of schools (not students) included in each subgroup are shown in Table 3.1.

TABLE 3.1: Description of Subsample Based on School Size

Description	Range	Mean	N
Small	0-199	129	58
Small/Medium	200-399	308	86
Medium	400-599	492	94
Medium/Large	600-799	691	30
Large	Over-800	1044	19

The literature on economies of scale in school operations was helpful in guiding judgment about how to partition the sample. Garms, Guthrie, and Pierce (1978) have summarized findings as follows:

> "There seems to be a traditional view that an elementary school of fewer than 300 students is uneconomical, as is ...an elementary school of more than 800 students (p. 365)."

More recently, one prominent educational economist (Levin 1983) has argued that it may be more efficient for school districts to maintain small schools, rather than to close them in response to declining enrollments, as small schools may produce greater student achievement. Therefore, while all schools greater than 800 were categorized as large, we chose a lower limit for small schools than that which might have been indicated by cost studies related to school size. One reason for this is to accentuate the differences between small and medium size schools in testing for a link to student achievement. In addition, in the future we plan to undertake a cost study of our own which takes into account the effectiveness of schools of different sizes in "producing" student achievement.

In order to simplify the presentation of the findings, only the data for small, medium, and large size schools are reported in the tables. Where relevant to the interpretation of the findings, the results related to small/medium and medium/large size schools will also be discussed. In Table 3.2 the means for resources which may be related to student achievement for small, medium, and large size schools are reported. The means for resources

TABLE 3.2: Means of Educational Inputs by School Size

VARIABLES	Small (0 - 199 Students)		Medium (400 -599 Students)	Large (Over 800 Students	
Intercept	1.000		1.000	1.000	
Sex (Male=1) - Student	0.510		0.501	0.498	
Race (White=1) - Student	0.875		0.764	0.504	
Childhood experience - Student	0.935		1.057	1.023	
Parental involvement - Student	1.841		1.882	1.850	
Economic status - Student	215.923	*	226.827	199.170	*
Administrators per student	0.005		0.004	0.004	
Teachers per student	0.058		0.056	0.052	
Office staff per student	0.017		0.018	0.025	
Teacher time in instruction	4.970		4.893	4.763	
Teacher preparation time	1.506		1.355	1.426	
Teacher time in administrative duties	0.788		0.767	0.775	
Total years teaching - Teacher	13.744	*	11.600	10.614	*
Highest degree - Teacher	2.458		2.450	2.559	
College math courses - Teacher	0.440		0.634	0.720	
Math inservice - Teacher	3.911	*	7.697	7.693	
Principals' leadership/Teachers' perception	2.958	*	3.347	3.706	*
Principals' encouragement/Teachers' perception	3.119		3.238	2.957	*
Pretest score	29.458	*	28.755	26.390	*
Pretest score - squared	961.191	*	924.071	774.590	*
Highest degree - Principal	2.933		3.012	3.000	
Total years teaching - Principal	10.961	*	9.588	9.617	
Total years administration - Principal	8.265	*	9.189	8.002	*
Math participation - Principal	8.023	*	9.472	10.750	*
Math involvement - Principal	8.632	*	11.016	15,157	*
Instructional leadership - Principal	49.648	*	52.882	54.783	*
Attitudes:					
Well-planned - Principal	3.008		3.358	3.148	
Well-planned - Teacher	2.769		2.651	2.155	*
Active leadership - Principal	2.914		3.208	3.234	
Active leadership - Teacher	2.365		2.256	2.105	
Work well together - Principal	3.568		3.549	3.253	
Work well together - Teacher	3.259	*	2.982	2.573	*
Well-informed - Principal	3.229		3.382	3.350	
Well-informed - Teacher	2.483		2.317	2.077	*
Conflicts identified - Principal	3.271		3.345	3.085	
Conflicts identified - Teacher	2.819	*	2.311	1.585	*
Post-Test Score	40.268	*	38.950	35.775	*

*Difference between the mean for this subgroup and the medium size school subgroup is significant at the 0.5 level.

in small or large schools are compared to those schools falling in the medium size range. Where the means from small and large schools differ significantly from those for medium size schools, the differences are noted.

Looking first at student characteristics, only the variable describing economic status shows any significant difference. On average, students in both small and large schools are less economically advantaged than those in medium size schools. This U-shaped relationship is not consistent across the five subgroups, however, as students in both small/medium and medium/large size schools are somewhat more economically advantaged than those in medium size schools. As we have not held constant for city type and geographical region, we anticipate that these factors may be responsible for the variation in economic status rather than school size per se.

Earlier we noted that previous studies have found school size to be correlated with such factors as student participation in extra-curricular activities, attendance, and satisfaction. However, these studies focused on high school students rather than elementary students as does this study. Given that elementary students have little choice about attendance or, perhaps, participation in extra-curricular activities and that measures of student satisfaction are not included as part of this data set, similar analyses have not been undertaken here.

No significant differences in administrators, teachers, or office personnel per student were found across small, medium, and large schools. Similarly no significant differences were found in the amount of time teachers reported devoting to instruction, preparation, or administration. With regard to teachers' years of experience, however, significant differences are apparent. Teachers in small schools have significantly greater years of experience than do those in medium size schools. This finding suggests than Dunathan's (1980) worry about high teacher turnover in small schools may be for nought. Instead, teachers in large schools tend to have fewer than average years of experience. (Teachers in both small/medium and medium/large schools have, on average, 12.5 years of experience.) However, this does not seem to be a major problem for districts with large schools as the relationship between teacher experience and student achievement is such that after three years of experience it is not clear that students are reaping additional benefits from the additional years of teacher experience for which the district must allocate scarce resources to "purchase" (Murnane 1975).

While averages for teachers across all three types of schools are similar in terms of the highest degree obtained and number of math courses taken, school size does seem to be related to the amount inservice work done in mathematics by teachers. Generally, those in larger schools spend more time related to inservice work in mathematics. Perhaps this stems from a relationship between the degree of discretionary funds available and school size. An equally plausible explanation is that, due to economies of scale, districts which have a high proportion of large schools feel it is cost-efficient to offer inservice in mathematics, rather than have teachers take courses outside the district which might be unrelated to district-wide programs.

The degree to which teachers perceive the principal as an effective leader is significantly related to school size. In small schools the principal is not perceived as an effective leader when compared to medium size schools and even less so when compared to large schools. One possible explanation is that in very small schools elementary principals may also take on duties which would be done by teachers in larger schools. Perhaps role ambiguity or the breadth of the job makes it difficult for principals in small schools to be effective leaders. Gersten and Carnine (1981) report that in order to have instructionally effective schools certain support functions must be carried out, though not necessarily by the principal. In larger schools, principals generally can delegate those instructional support tasks to other school personnel in areas they themselves are weakest, or perhaps like least. Therefore, in larger schools where a principal has more discretion over which tasks he or she will perform, it seems plausible that the principal may be seen as a stronger leader.

Pretest scores are significantly higher in small schools and significantly lower in large schools when compared with the scores of students attending medium size schools. However, while we do hold constant for a number of student, teacher, and principal characteristics it is likely that at least part of this difference can be attributed to factors other than school size. One set of variables which we have not included, the degree to which classrooms are heterogeneously grouped according to ability, race, and socio-economic status may have accounted for some of the difference in pretest scores. In smaller schools it is less likely that students will be tracked by ability levels (which in turn may be correlated with SES and race). There is some evidence, though the results are mixed, that achievement scores for lower ability students may be positively affected by higher ability peers in the classroom (Murnane 1975). Similarly, lower SES students may benefit from classmates who are more economically advantaged. Hanushek (1972) reports that achievement of students may higher, on average, when they are in integrated classrooms. Consequently, if these types of conditions are, in fact, more prevalent in smaller schools, it is likely that school size alone is not primarily responsible for the difference in means for students' pretest scores in mathematics across small, medium, and large size schools.*

*We are grateful to Frank L. Smith for bringing this additional path of inquiry to our attention.

School size does seem to be related to many principal characteristics. Looking first at school size, although the difference is insignificant, principals in smaller schools generally did not attain degrees as high as those earned by principals in medium size or large schools. Cross-tabulations not reported here show that approximately 10 percent of principals in small schools do not hold master's degrees, compared to less than 3 percent for principals employed in other schools, and that none of the principals in our sample of small schools hold doctorates. (The latter finding is not surprising as only 2 percent of the principals in our sample of 328 schools hold doctorates.) Like teachers in small schools, principals in these schools have more years of teaching experience than do those in medium size or large schools. However, principals in both small and large schools have less experience as administrators than do those in moderately sized schools.

Principals were asked "How much time have you spent during this school year participating in activities related to curriculum development (in mathematics) in your school?" The pattern here was similar to that related to time teachers spent in inservice related to mathematics: those in moderately sized schools spent more time than those in small schools (9.5 versus 8 hours per year) and those in larger schools spent significantly more time developing mathematics curriculum (10.8 hours) than those in moderately sized schools. The same general pattern exists with respect to the number of hours during the year that principals "devoted to needs assessment, program planning, and program evaluation" for math activities in their schools.

Both principals and teachers were asked about the degree to which they agreed with the following statements:

* The school's programs are well-planned and clear.
* The principal provides active leadership to reading and

mathematics programs.

* Teachers in this school work well together.

* Administrators keep teachers well-informed.

* Conflicts among individuals are identified and faced, not allowed to fester.

The responses were coded as follows: strongly disagree = 1, disagree = 2, agree = 3, and strongly agree = 4.

The results are fairly consistent and interesting. Teachers in large schools seem, in many ways, to be less satisfied than teachers in moderately sized or small schools. They gave significantly lower scores to the following statements:

* The school's programs are well-planned and clear.

* Teachers in this school work well together.

* Administrators keep teachers well-informed.

* Conflicts among individuals are identified and faced, and not allowed to fester.

Teachers in large schools semed to be particularly dissatisfied with the way conflicts were managed. In fact, this complaint seems to be common across all categories (including small/medium and medium/large) with the possible exception of teachers in small schools. In contrast, in smaller schools closer ties among teachers seem to improve not only conflict management, but in general, teachers report that they "work well together" more often than those in schools of greater size.

<u>Differences in the Effectiveness of Resources</u>

We also examine the way in which school size may make a difference in the degree to which resources affect student achievement. For example, time teachers spend in instruction time may be used more effectively in medium sized schools than in large schools. (Actually, our results show no significant difference when we hold constant for the other variables included in the regression.) The coefficients for the variables included in our regression are listed in Table 3.3. Where the coefficients for small schools or large schools deviate significantly (at the 0.5 level) from the coefficients for medium size schools the difference is noted.

When comparing large schools to medium size schools, the largest positive changes in student achievement stemmed from the influence of the following variables: race, administrators per student, teachers per student, time teachers spend in preparation, amount of time teachers spend in inservice in mathematics, and teachers' perception that the principal provides active leadership to the mathematics program. As school size increases from 400-599 students to over 800 students, the strongest negative influences on student achievement include: office personnel per student, teachers' highest degree, and the degree to which teachers feel the principal is encouraging.

The increasing influence of race on student achievement as school size increases may have important policy implications. Black students appear to be at a greater disadvantage in larger schools with respect to student achievement. While this difference may partially stem from the fact that classes in large schools may be less likely to be heterogenously grouped than those in small schools, there may be other explanations for this problematic result. Since large schools also tend to include a high proportion of non-white students it is possible that where white students are a minority they are given increased teacher attention, perhaps in a subconscious attempt to minimize white flight. At any rate, there is a danger that discrimination with respect to the amount of human resources allocated to students might be more difficult to discern and/or correct in larger schools.

As schools decreased in size from 400-599 students to less than 200

TABLE 3.3: Educational Production Functions by School Size

VARIABLES	COEFFICIENTS Small (0 - 199 Students)	Medium (400 -599 Students)	Large (Over 800 Students
Intercept	.45	14.66	14.84
Sex (Male=1) - Student	-2.01	-2.07	-1.88
Race (White=1) - Student	1.72	1.54	1.34
Childhood experience - Student	0.09	-0.09	-0.0097
Parental involvement - Student	0.05	0.03	0.12
Economic status - Student	0.03	0.02	0.015
Administrators per student	51.34	-105.19	-202.64
Teachers per student	90.37 *	-8.37	24.23 *
Office staff per student	113.27 *	-36.59	-14.04 *
Teacher time in instruction	0.06	0.47	0.45
Teacher preparation time	0.79	-0.06	0.22
Teacher time in administrative duties	0.78	-0.01	-0.24
Total years teaching - Teacher	0.04	-0.01	0.022
Highest degree - Teacher	-1.73	-0.33	-0.78
College math courses - Teacher	0.74	-0.52	0.11 *
Math inservice - Teacher	0.03	0.01	-0.018 *
Principals' leadership/Teachers' perception	0.02	0.11	0.053
Principals' encouragement/Teachers' perception	-0.53	-0.20	-0.39
Pretest score	0.90	0.86	0.92
Pretest score - squared	-0.00	0.00	-0.00063
Highest degree - Principal	2.08	-0.91	-2.03
Total years teaching - Principal	0.06	0.11	0.06
Total years administration - Principal	0.12	0.05	0.08
Math participation - Principal	-0.00	-0.06	-0.04
Math involvement - Principal	0.06	0.06	0.06
Instructional leadership - Principal	-0.26 *	0.03	0.01
Attitudes:			
Well-planned - Principal	0.49	-0.44	0.37
Well-planned - Teacher	-0.51	-0.25	0.12 *
Active leadership - Principal	-1.13	-0.89	0.20 *
Active leadership - Teacher	1.57 *	0.13	0.14
Work well together - Principal	-1.07 *	0.85	0.35
Work well together - Teacher	0.31	-0.05	-0.03
Well-informed - Principal	2.24 *	-0.67	0.03 *
Well-informed - Teacher	0.14	-0.24	-0.12
Conflicts identified - Principal	1.33	-0.13	0.11
Conflicts identified - Teacher	-0.11	0.32	-0.01 *
R^2	.5902	.5822	.4990

*Difference between the coefficient for this subgroup and the medium size subgroup is significant at the .05 level.

students, changes in the coefficients for the following variables were related to positive increases in student achievement (per unit of the input variable): teachers per student, office personnel per student, the degree to which teachers perceive that principals provide active leadership to the mathematics program, and the degree to which principals perceive that they keep the teachers well informed.

As school size decreases, the following variables seem to have a weaker or more negative relationship with student achievement in mathematics: the amount of time principals report spending in activities related to instructional leadership and the degree to which principals perceive that teachers in the school work well together.

<u>Overall Impact of School Size on Student Achievement</u>

In order to account for the potential impact of school size on student achievement it is necessary to jointly determine how school size affects the difference in levels of resources available for producing achievement (measured by a change in means) as well as the way in which resources available actually related to student achievement (measured by a change in coefficients as school size changes). The combined effect of these two sets of changes are located in Table 3.4 (comparing small schools to medium sized schools) and Table 3.5 (comparing large schools to medium sized schools). To fully account for the changes in education production as we alter school size, however, we must also consider a third component, the product of those changes in means and coefficients. Thus, our analysis here is similar to that in Chapter 2.

When one examines the combined effects on student achievement as we move from medium size schools to small schools the impact of school size appears significant. First, we examine how changes in levels of resources available, as one of three components, will influence student achievement in mathematics as we move from medium size school, to small schools. To do this we multiply the differences in levels of resources available between small schools and medium size schools (ΔX) times the coefficients for medium size schools (which serves as the quasi-control group). Looking at Table 3.4 we see that the sum of these ($\beta \Delta X$) is 1.27. (Note that this includes the significant differences in means for the individual variables which were discussed earlier as well as those which are relatively minor.) This tells us that the influence of the changes in <u>levels</u> of resources available to promote student achievement accounts for 12.7 percent of the average gain in mathematics achievement. In other words, small schools seem to have greater amounts or levels of resources which are shown to have a positive net influence on student achievement from the pretest to the posttest. However, this estimate may have an upward bias if we have not accounted for other variables which are predictors of student achievement in mathematics which might be correlated with school size.

Secondly, we examine how the way in which resources are utilized affects student achievement, this time holding constant for the amounts or levels of various resources available by using medium-sized schools as a quasi-control group. Therefore, we multiply the differences in coefficients between small and medium sized schools ( ) by the means for the medium sized schools (X). The sum of the effects of these individual changes in coefficients ( ), as shown in Table 3.4, is .048. Therefore, the differences in the utility of these resources for "producing education" accounts for about five percent of the average gain in mathematics achievement from pretest to posttest score.

Finally, we must take into account any interactive effects which occur as a result of differences in both the level of resources available in

TABLE 3.4: Effects on Student Achievement of Differences Between Small Schools and Medium Size Schools in Education Inputs and Educational Production Functions

VARIABLES	$\beta\Delta\chi$	$\beta\Delta\chi$	$\beta\Delta\chi$
Intercept	0.000	14.209	0.000
Sex (Male=1) - Student	-0.019	0.033	0.001
Race (White=1) - Student	0.170	0.157	0.020
Childhood experience - Student	0.011	0.166	-0.022
Parental involvement - Student	-0.001	0.035	-0.001
Economic status - Student	-0.197	1.473	-0.075
Administrators per student	-0.091	0.262	0.046
Teachers per student	-0.011	5.690	0.127
Office staff per student	0.051	2.527	-0.207
Teacher time in instruction	0.036	-2.028	-0.032
Teacher preparation time	-0.009	1.277	0.128
Teacher time in administrative duties	-0.000	0.626	0.016
Total years teaching - Teacher	-0.028	0.712	0.112
Highest degree - Teacher	-0.003	-3.448	-0.012
College math courses - Teacher	0.101	0.551	-0.244
Math inservice - Teacher	-0.021	0.109	-0.105
Principals' leadership/Teachers' perception	-0.041	-0.242	0.032
Principals' encouragement/Teachers' perception	0.023	-1.049	0.040
Pretest score	0.606	0.943	0.023
Pretest score - squared	0.005	-1.361	-0.052
Highest degree - Principal	0.072	8.777	-0.239
Total years teaching - Principal	0.157	-0.604	-0.076
Total years administration - Principal	-0.043	0.569	-0.064
Math participation - Principal	0.091	0.490	-0.088
Math involvement - Principal	-0.132	-0.002	0.000
Instructional leadership - Principal	-0.098	-14.387	0.937
Attitudes:			
Well-planned - Principal	0.154	2.799	-0.326
Well-planned - Teacher	-0.029	-0.746	-0.032
Active leadership - Principal	0.263	-0.706	0.071
Active leadership - Teacher	0.015	3.395	0.157
Work well together - Principal	0.016	-6.877	-0.036
Work well together - Teacher	-0.015	1.176	0.100
Well-informed - Principal	0.103	9.406	-0.446
Well-informed - Teacher	-0.039	0.936	0.063
Conflicts identified - Principal	0.010	4.805	-0.109
Conflicts identified - Teacher	0.161	-1.208	-0.218
Sum	1.2703	.0475	-0.5121

Notes: β refers to the coefficients of the medium size school production function in Table 3.3. X refers to the medium size school means from Table 3.2. The changes are calculated by subtracting the medium size school value from the corresponding small school value.

small schools, as opposed to medium size schools, and the way in which they operate. As with the impact of the differences in means and the differences in coefficients between the two sub-groups, the sum of the interactive effects is relatively minor. It accounts for only five percent of the gain in student achievement in mathematics over the time period. In addition, as the interactive effect is negative, this deflates the overall impact of decreasing the size of the school from 400-599 to less than 200. When one takes all three components into account, the overall change in student mathematics achievement is .81, or about 8 percent of the typical gain in student achievement.

On the other end of the continuum, we can see from Table 3.5 that the impact of school size seems relatively great when we compared the educational production functions for students educated in large schools (over 800 students) to that for students educated in medium size schools (400-599 students). Looking first at the effects of the differences in means regarding amounts or levels of resources available for educational production between large schools and medium size schools ($\beta\Delta\chi$), again using the medium sized schools as a quasi-control group, we can see that the difference in environment factors and resources available is -320 or nearly a third of the average gain in achievement as we move to large schools. The overall impact of the differences between large and medium size schools in the effect resources have ($\chi\Delta\beta$) is negligible. The sum of the interaction effects between differences in resources and differences in the effect of ($\Delta\chi\Delta\beta$) is also small.

The number of teachers per student is only slightly lower in large schools than medium size schools, but it seems to have a relatively major negative impact due to the large difference in coefficients between these large and medium size schools. Similarly, the difference in the mean for

TABLE 3.5: Effects on Student Achievement of Differences Between Large Schools and Medium Size Schools in Education Inputs and Educational Production Functions

VARIABLES	$\beta\Delta\chi$	$\chi\Delta\beta$	$\Delta\chi\Delta\beta$
Intercept	0.000	0.166	0.000
Sex (Male=1) - Student	0.007	0.096	-0.001
Race (White=1) - Student	-0.400	-0.100	0.051
Childhood experience - Student	0.003	0.082	-0.003
Parental involvement - Student	-0.001	0.156	-0.003
Economic status - Student	-0.498	-0.601	0.083
Administrators per student	0.023	-0.368	0.021
Teachers per student	0.034	1.703	-0.133
Office staff per student	-0.239	0.558	0.147
Teacher time in instruction	-0.074	-0.096	0.003
Teacher preparation time	-0.004	0.395	0.019
Teacher time in administrative duties	-0.000	-0.177	-0.002
Total years teaching - Teacher	0.013	0.381	-0.035
Highest degree - Teacher	-0.036	-1.149	-0.049
College math courses - Teacher	-0.045	0.448	0.053
Math inservice - Teacher	-0.000	-0.180	0.000
Principals' leadership/Teachers' perception	0.038	-0.194	-0.018
Principals' encouragement/Teachers' perception	0.056	-0.568	0.053
Pretest score	-2.041	1.513	-0.135
Pretest score - squared	-0.021	-0.595	0.114
Highest degree - Principal	0.011	-3.361	0.013
Total years teaching - Principal	0.003	-0.525	-0.002
Total years administration - Principal	-0.056	0.280	-0.041
Math participation - Principal	-0.080	0.266	0.031
Math involvement - Principal	0.230	0.113	0.031
Instructional leadership - Principal	0.057	-2.528	-0.087
Attitudes:			
Well-planned - Principal	1.716	0.220	-0.014
Well-planned - Teacher	-0.038	0.787	-0.181
Active leadership - Principal	6.430	2.206	0.017
Active leadership - Teacher	0.525	0.001	-0.000
Work well together - Principal	-3.375	-1.637	0.148
Work well together - Teacher	0.073	0.058	-0.009
Well-informed - Principal	6.605	2.346	-0.022
Well-informed - Teacher	0.916	0.243	-0.028
Conflicts identified - Principal	-1.629	0.787	-0.066
Conflicts identified - Teacher	-1.415	-0.521	0.238
Sum	-3.195	.207	.196

Notes: β refers to the coefficients of the medium size school production function in Table 3.3. X refers to the medium size school means from Table 3.2. The changes are calculated by subtracting the medium size school value from the corresponding large school value.

principals' highest degree between large and medium size schools accounts for was minor, but the negative impact was significant. (This is consistent with past research described earlier.) Ironically, the time principals from large schools reported spending in needs assessment, program planning, and program evaluation related to mathematics was found to have a significant negative impact on students' achievement in mathematics. Hopefully, this means that the correlation may be reversed. Where mathematics achievement tends to be low when compared to similar schools, principals may then begin to spend more time (or report to spend more time) engaged in needs assessment, program planning, and program evaluation to attempt to improve the mathematics program.

The overall difference in the way large schools and medium size schools produce education accounts for slightly more than one-quarter of the average gain in student achievement scores in mathematics. This means that student achievement in larger schools is substantially lower on average than moderately sized schools, even when when certain student, teacher, principal, school climate, and time on task variables are taken into account. This difference is much larger than the difference between small and moderately sized schools.

IV. Conclusion

Our research identified a number of input variables which differ significantly between schools of small and medium sizes and large and medium sizes (measured according to number of students in attendance). Interestingly, there were fewer significant differences based on student background characteristics than for those variables over which educational policymakers presumably have more control, such as teacher characteristics, principal characteristics, school climate, and number of school personnel per student. The effect that some of the ? types of resources had on student achievement also seemed to be significantly influenced by the school size. However, when we examined the overall net impact of school size on student achievement the differences between small schools and medium size schools was not large, only about 8 percent of the average gain in test scores. However, large schools seem to be significantly less effective in producing student achievement. Differences in resources and in the effect of resources on student achievement in large schools are associated with lower test scores, by about 28 percent of the average gain in test scores. The results lead us to hypothesize, as suggested by Henry Levin (1983), that students in large schools may be better served if these schools were to be divided into mini-schools. In this way, smaller groups of students, teachers, and administrators may facilitate better coordination of the instructional program.

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